

# **Processes in Marginal Seas -and- ASIAEX Project Management**

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## **LONG-TERM GOAL**

My long-term goal is to enhance our understanding of coastal oceanography by means of applying simple dynamical theories to high-quality observations obtained in the field. My primary area of expertise is physical oceanography, but I also enjoy collaborating with biological, chemical, acoustical, and optical oceanographers to work on interdisciplinary problems. I collaborate frequently with numerical modelers to improve their predictive capabilities of Navy-relevant parameters in the littoral zone.

## **OBJECTIVES**

The objective of these two closely-related grants is plan and execute a multi-national oceanographic field program in the East and South China Seas to investigate how the complex littoral environment (i.e., its water column, boundary, sediment and sub-bottom structure and inhomogenities) affects the ray paths, mode structure, propagation loss, and temporal and spatial (both vertical and horizontal) coherence for low-to-intermediate frequency (50-4000 Hz) acoustic transmissions in shallow water

## **APPROACH**

A three-pronged approach was executed: 1) Analyze previously obtained data sets in the Japan (East) Sea and South China Sea; 2) Conduct a pilot study from the R/V ROGER REVELLE in the East China Sea during spring 2000; and 3) Continue workshops and planning activities for the primary field effort to be conducted during spring 2001.

The main field program will consist of two distinct experiments, a reverberation experiment and a volume interaction experiment, which collectively form the Asian Seas International Acoustics Experiment (ASIAEX). The goal of the reverberation experiment is to *Develop models that can predict*

*the mean reverberation level and fluctuations using measured environmental parameters.* The goal of the volume interaction experiment is *to understand acoustic propagation through shallow water when strong oceanic variability is present.* Oceanographic parameters deemed useful for this study include the strength, location, and variability of the dominant T, S, and density fronts, the strength and seasonal variability of the vertical stratification, the structure of the alongshore currents over the continental slope, and the nature and frequency of the Kuroshio variability. The detailed geophysical characteristics of the bottom and sub-bottom structure are also required.

## **WORK COMPLETED**

**Analysis:** Efforts during this grant period focussed on an outstanding data set from the Japan (East) Sea collected from the R/V ROGER REVELLE during June 1999 by Lynne Talley (CTD and hull-mounted ADCP data) and Carin Ashjian et al. (towed CTD data from the video plankton recorder). Talley et al. will focus on the ventilation and large-scale processes in the sea while Ashjian et al. will study zooplankton species distribution and abundance using the VPR data. The investigators have graciously shared the data with S. Ramp for the purpose of analyzing the mesoscale variability in the Ulleung Basin. Most of the effort to date has been devoted to calibrating and carefully combining the two (deep, moderate resolution and shallow, high resolution) data sets to obtain surface-to-bottom T/S distributions (and derived parameters), resolved to the scales of the VPR data. Several methods including linear interpolation, objective analysis and gravest empirical mode (GEM) techniques are still being compared and contrasted at this time. Several interesting oceanographic features, robust regardless of the data handling technique, have nevertheless been resolved.

**Pilot study:** The pilot study was carried out during 8 April to 2 May 2000 in the East China Sea. The actual study was confined to 15 days from 11 to 26 April within a region bounded by 28-30°N and 126° 30' to 128°E. The cruise was delayed a week due to research vessel clearance problems. Profs. Ramp and Chiu spent an intense week negotiating with Beijing and Tokyo to secure the necessary permissions. Both Professors also served as principal investigators on board the cruise. The cruise itself was spent approximately 80% sub-bottom profiling, 10% CTD sections, and 10% mooring deployments and recoveries. Fishing effort was a serious problem and all the moorings at the shallower site 1 were lost. The cruise was staged from Pusan, South Korea and included port stops in Shanghai, PRC and Naha, Okinawa before terminating in Kaohsiung, Taiwan.

**Planning:** A workshop was held in Kailua Kona, Hawaii during June 21-23, 2000. There were 61 attendees from the United States, People's Republic of China, Taiwan, Singapore, Japan, Korea, and Russia. S. Ramp organized and convened this workshop with administrative assistance from Mrs. Beverly Kuhn at ONR. Results from the ECS pilot study from REVELLE and an SCS pilot study conducted by Taiwan were presented. A representative from all the major participating programs presented a summary of their plans and expectations for ASIAEX 2001. Breakout groups were formed for the two experiments, reverb and volume interaction, to finalize the scientific rationale and implementation plan for each. Publication and data distribution issues were discussed. Workshop reports for the Kona meeting (Ramp) and the previous years Girdwood, Alaska meeting (Denner, Chiu and Ramp) were completed. Professor Chiu served as the primary author of the Girdwood report following the untimely death of Dr. Denner.

## RESULTS

***Japan (East) Sea.*** The most dramatic feature in the data set is the collision point between the northward-flowing East Korean Warm Current (EKWC) and the southward-flowing North Korean Cold Current (NKCC) at about 37 degrees north latitude along the Korean coast. At 40 m depth near the collision point, the NKCC has T less than 4 deg C and S about 34.05, while the EKWC has T greater than 16 deg C and S greater than 34.45. This leads to some of the strongest fronts ever observed in the upper ocean. The NKCC subducts beneath the EKWC south of the collision point. North of the separation point, a thin layer of subtropical water overrides the NKCC, resulting in a very shallow thermocline ranging from greater than 20 deg C at the surface to less than 4 deg C at 40 m. In this snapshot, the feature commonly known as the Ulleung Basin Eddy is actually a realization of the separating western boundary current and its first downstream meander.

***East China Sea:*** The oceanography of the pilot study area was dominated by the Kuroshio flowing NE along the continental shelf break (Figure 1). A cross-shelf section of the temperature and salinity structure (Figure 2) shows the strength of the fronts and associated geostrophic flow. The core of the current is shown by the high salinity centered near 150 m depth. Associated ADCP data showed maximum alongshore flow of about 120 cm s<sup>-1</sup> in the current. The across-shore flow had a maximum of about 30 cm s<sup>-1</sup> right at the shelf break, which may assist the barotropic tide in the generation of nonlinear internal waves (solitons). These solitons were observed in the current meter data from Mooring 2 (Figure 1) and in the synthetic aperture radar data. There is thus a rich and energetic range of scales in these processes to study during the main field program.

## IMPACT/APPLICATION

The ASIAEX program is a follow-on to the New England Shelfbreak Primer experiment and as such will advance the state of the art in shallow water acoustic propagation prediction. The 2001 field program will use more sophisticated acoustic sources and arrays, multiple towed vehicles, and alongshore as well as across-shore array configurations to better elucidate the subtle relationships between the water column variability, bottom and sub-bottom structure, and acoustic propagation loss.

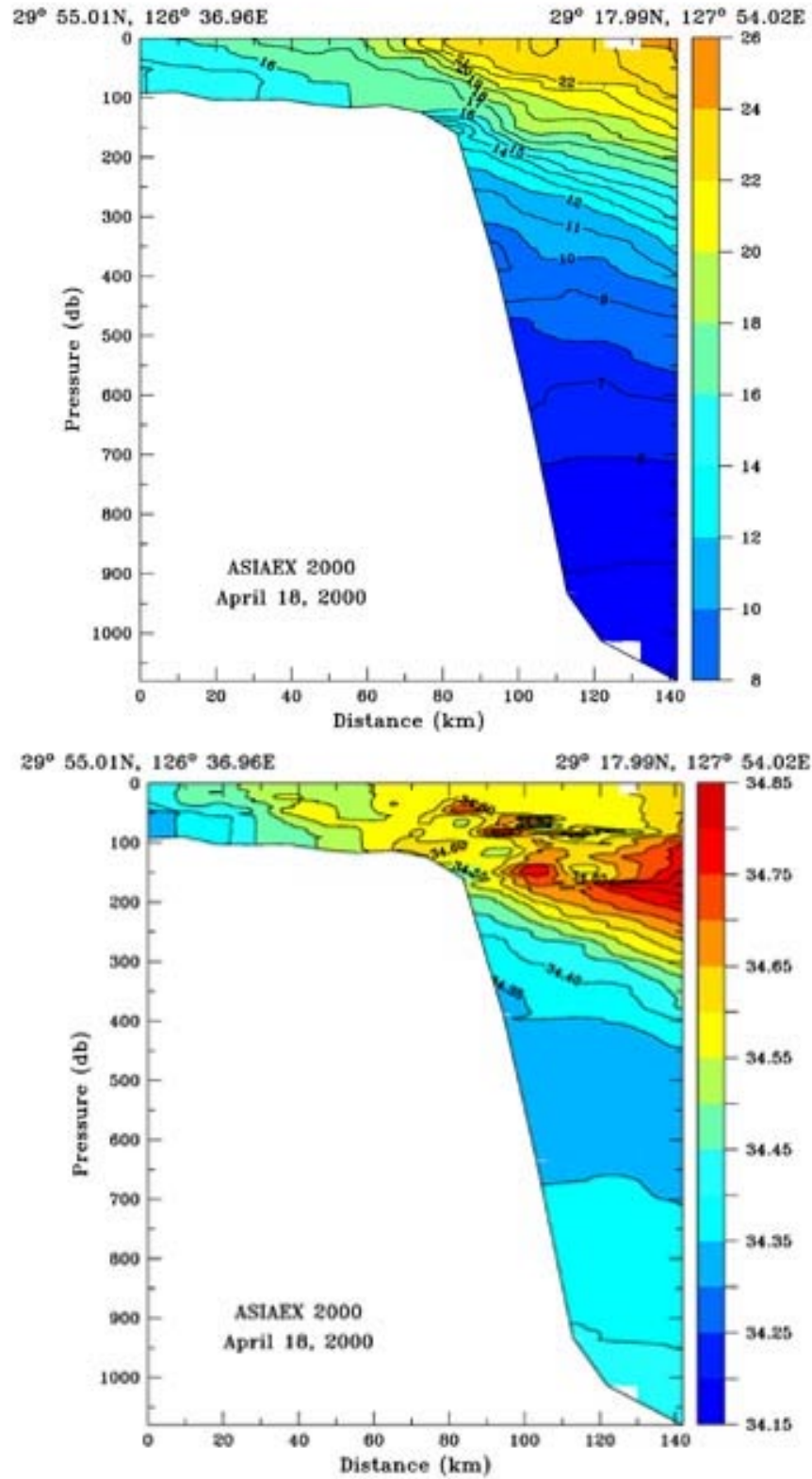
## TRANSITIONS

None yet.

## RELATED PROJECTS

None





*Figure 2. Temperature (top) and salinity (bottom) along the across-shelf section shown by the blue line in Figure 1.*

## PUBLICATIONS

1. Noble, M. A. and S. R. Ramp, 2000: Subtidal currents over the central California slope: Evidence for offshore veering of the undercurrent and for direct, wind-driven slope currents. *Deep-Sea Res. II*, **47**, 871-906.
2. Chereskin, T., M. Morris, P. P. Niiler, S. R. Ramp, P. M. Kosro, R. L. Smith, and C. A. Collins, 2000: Mesoscale variability of the California Current System from eddy-resolving moored measurements. *J. Geophys. Res.*, **105**, 1245-1270.
3. Denner, W. W., C.-S. Chiu, and S. R. Ramp, 2000. Report on the Office of Naval Research Phase III International Workshop on Shallow-Water Acoustics, Alyeska Resort, Girdwood, Alaska, July 12-15, 1999. *Naval Postgraduate School Technical Report* NPS-OC-00-001PR, 40 pp.
4. Ramp, S. R., 2000. WORKSHOP REPORT: The Asian Seas International Acoustics Experiment (ASIAEX). Final planning meeting, Kailua Kona, Hawaii, June 21-23, 2000. *Naval Postgraduate School Technical Report* NPS-OC-00-XXXXX, 31 pp.